

# The TPC and SPIDER Projects

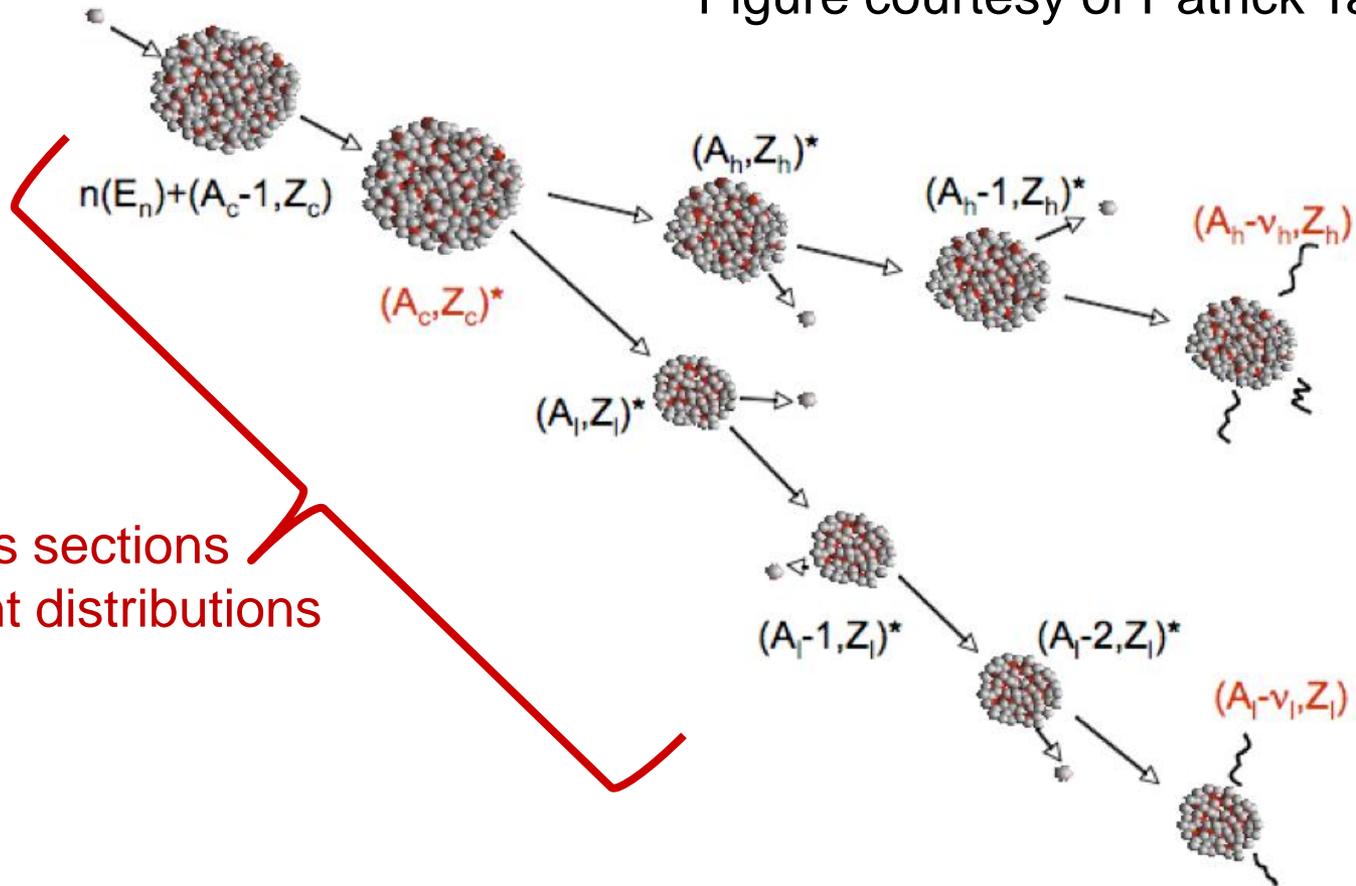
**Rhiannon Meharchand**

Los Alamos National Laboratory

On behalf of the  **NIFFTE** and **SPIDER**  
collaborations

# Our place in the bigger picture

Figure courtesy of Patrick Talou



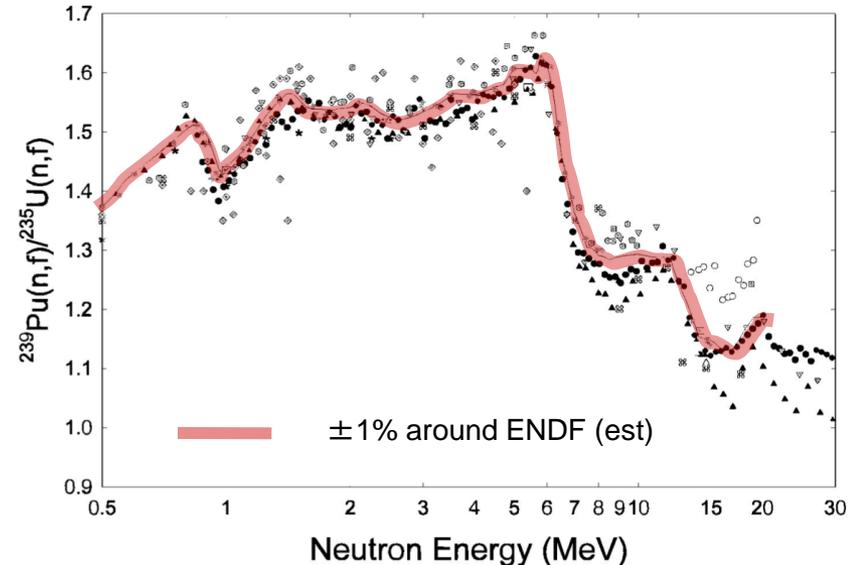
Fission cross sections  
and fragment distributions

# Neutron Induced Fission Fragment Tracking Experiment

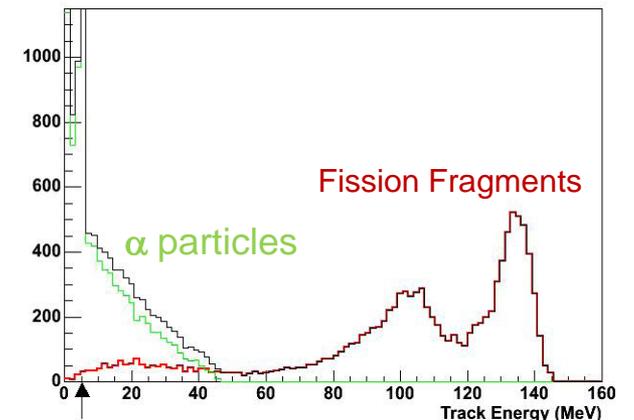


# Goals

- Implement a fission cross section measurement program with the goal of providing the most needed measurements with unprecedented precision and accuracy
- Address major sources of systematic uncertainties that have plagued previous measurements:
  - Misidentification of fission products and alpha decays
  - Sample and beam non-uniformities
  - Uncertainties inherent to reference standards

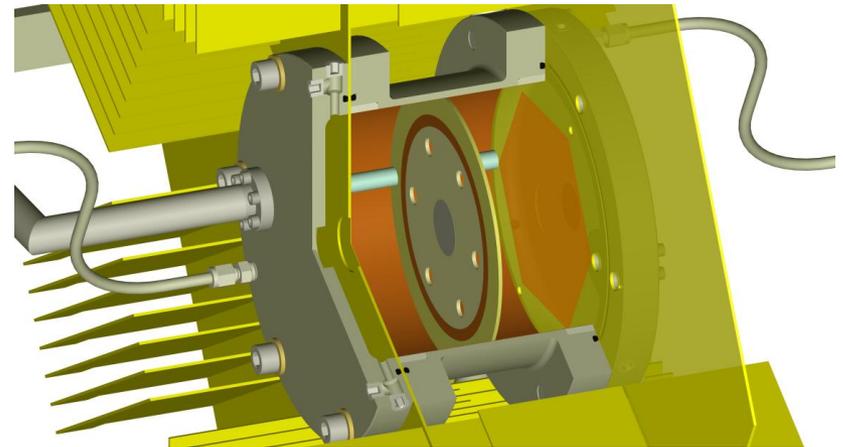
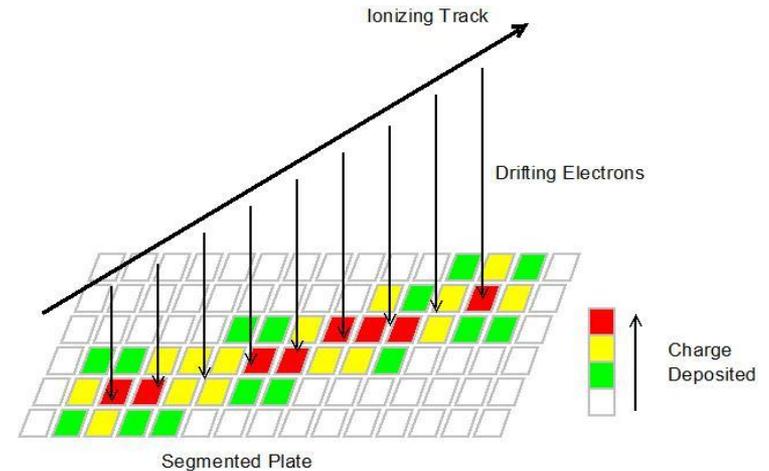


Staples & Morley; Nucl. Sci. and Eng. v.129 (June 1998)

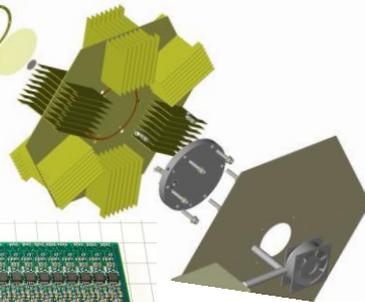
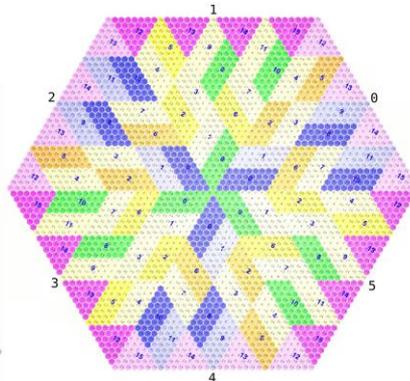
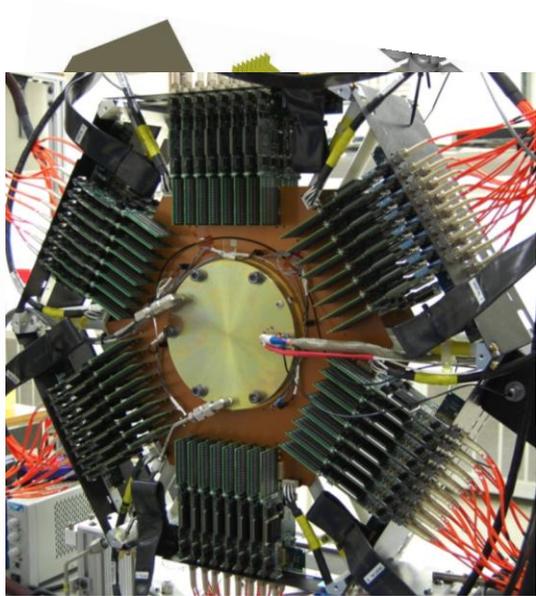


# The NIFFTE Time Projection Chamber (TPC)

- **First application of TPC technology to fission research**
- **3-D particle tracking**
  - Enables autoradiograph of target material and neutron beam profile
  - Better particle ID capabilities
- **Near- $4\pi$  solid angle coverage**
  - Detection of both light and heavy fragments
- **Designed to use hydrogen gas in active volume**
  - Normalize data to H(n,n)H elastic scattering cross section



# Highly advanced technology, software, and controls



Thin (~100 ug/cm<sup>2</sup>) actinide samples, variable size/shape deposits



Field cage steps down uniformly from -1400V → -340V over 5.4 cm



Pressure vessel holds up to 5 bar



2976 readout pads *per side*



192 preamp (analog) + EtherDAQ (digital) card pairs



Remote monitoring and control of HV, LV, Gas Handling and Slow Control systems



Complete software suite including online monitoring and detailed simulation

CAL POLY

# Beam measurements with the TPC

## ■ 2010:

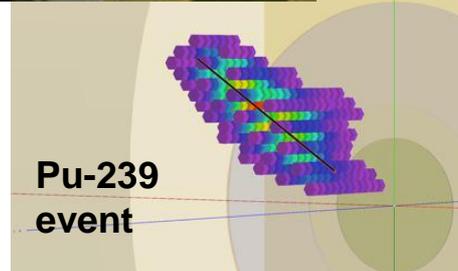
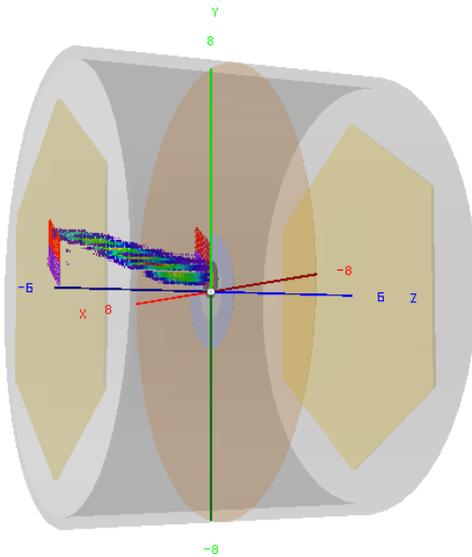
- C backing (64 channels)
- U-238 (64 channels)
- U-238 (192 channels)

## ■ 2011(Nov) - 2012 (Feb):

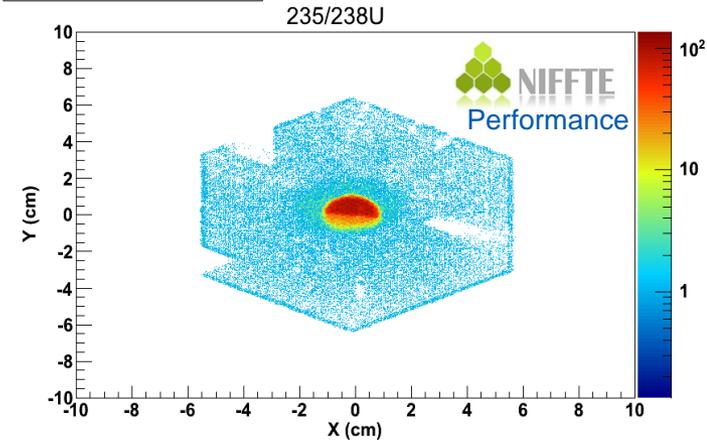
- 496 channels (1/12 TPC)
- U-238 (15 days, 48% production)
- U-238/U-235 #1 (19 days, 72%)
- U-238/U-235 #2 (16 days, 69%)
- Pu-239 (21 days, 45%)

## ■ 2012:

- 2976 channels (1/2 TPC)
- Fast Timing (TOF)
- U-238/U-235 (~24 days production)
- Pu-239/U-235 (~24 days)
- More U-238/U-235...

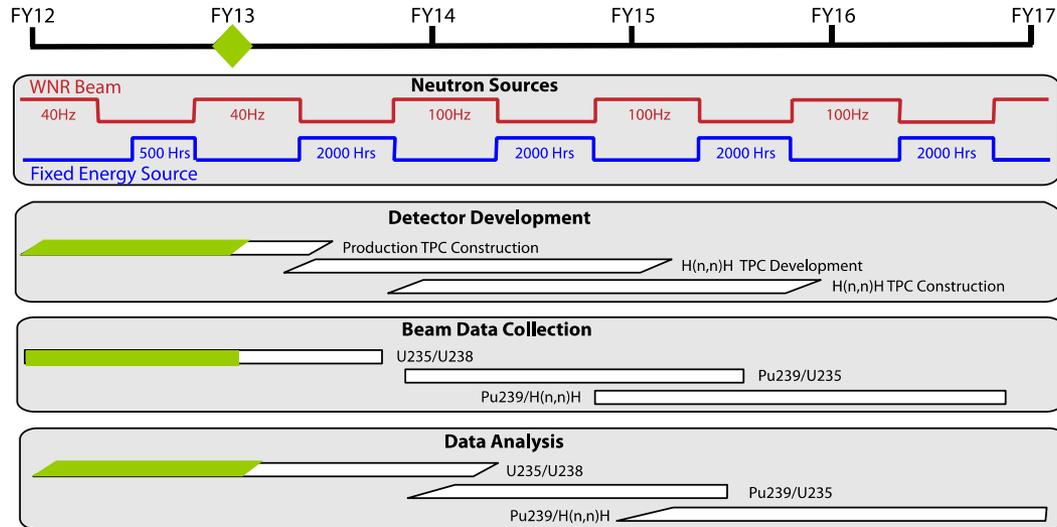


Track X-Y Plane Vertex  
Fission Fragments

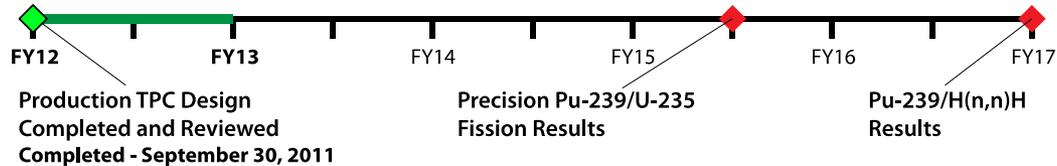


# Current Status

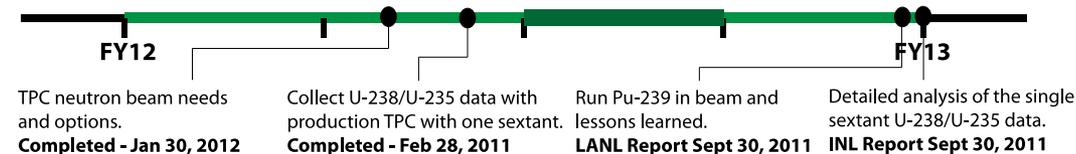
## TPC Project Timeline



## Major Milestones/Deliverables Timeline



## FY12 Supporting Milestones/Deliverables



# SPECTROMETER for Ion DETERMINATION in fission Research

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## SPIDER



# The SPIDER instrument



## ■ Goal

- Develop an instrument for measuring fission fragment properties (mass, charge and kinetic energy) with high resolution

## ■ Applications

- Fission yields for nuclear applications
- Improved understanding of the fission process

## ■ Target accuracies

- 1 unit resolution for mass and charge
- 0.5% energy resolution for light fragments
- >1 % detection efficiency

## ■ Collaboration

- **LANL** (F. Tovesson, C. Arnold, T. Bredeweg, T. Burr, E. Esch, M. Jandel, J. Jorgensen, A. Laptev, J. Lestone, P. Lisowski, R. Meharchand, K. Meierbachtol, P. Moller, R. Nelson, J. O'Donnell, B. Perdue, T. Renshaw, A. Sierk)
- **UNM** (A. Hecht, R. Blakely, D. Mader, E. Dughie)
- **CSM** (U. Greife, B. Moore, D. Shields, B. Moore)
- **LBL**: J. Randrup
- **LLNL** (L. Snyder)
- **Slovak Academy of Sciences** (J. Kliman)



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Slide 11

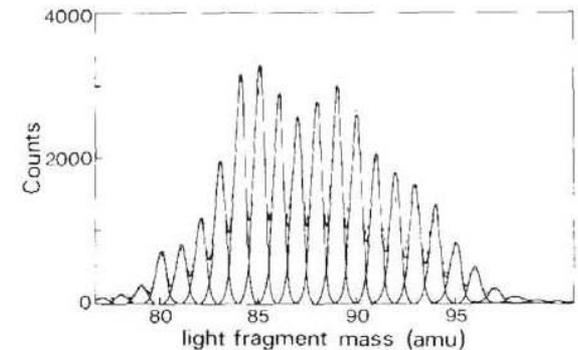
# The 2E-2V method

- First demonstrated in mid 1980's
- <1 amu mass resolution of light fragments
- ~1 unit charge resolution for light fragments
- (A,Z,TKE) yields for both fragments
  - Significant information about the fission process

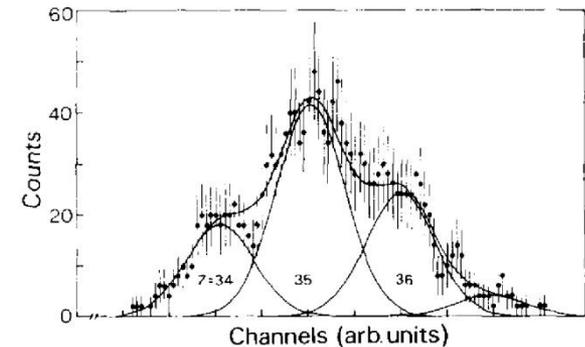
$$M = \frac{2Et^2}{l^2}$$

$$\frac{\delta M}{M} = \sqrt{\left(\frac{\delta E}{E}\right)^2 + \left(2\frac{\delta t}{t}\right)^2 + \left(2\frac{\delta l}{l}\right)^2}$$

FPY measured with COSI-FAN-TUTTE



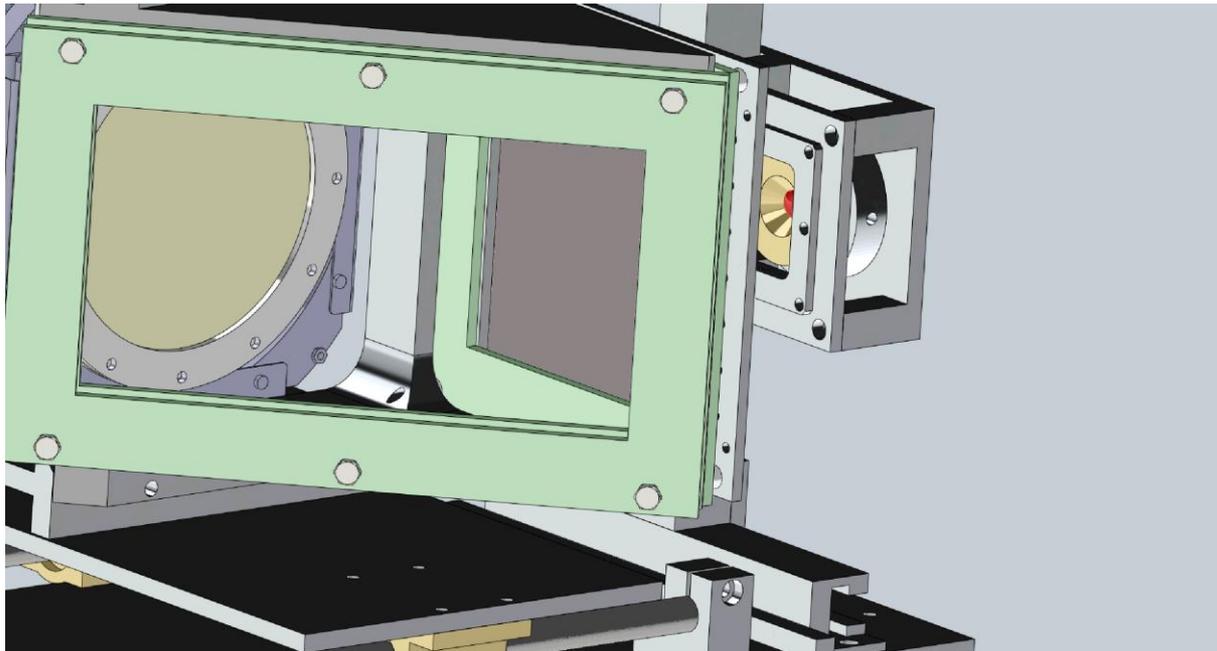
Nuclear charge distribution for A=87



# SPIDER system

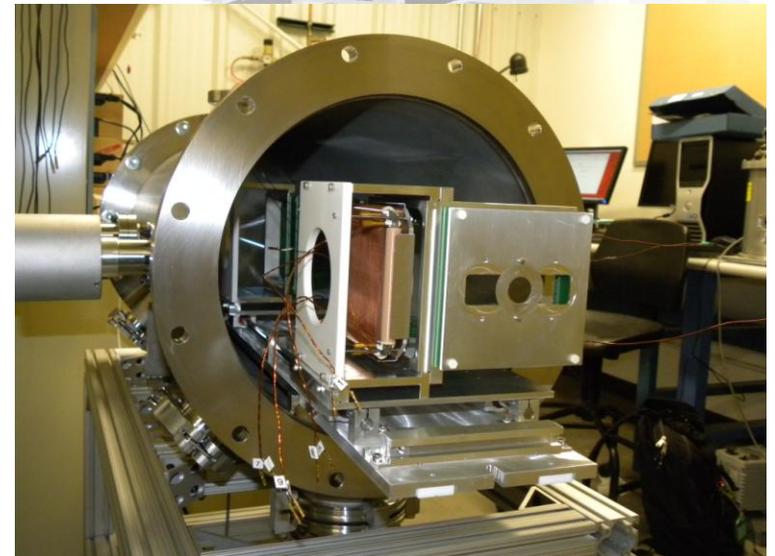
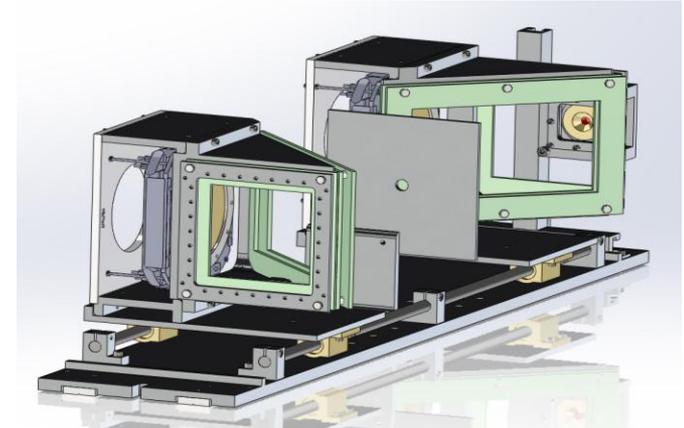
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Movie courtesy of Justin Jorgenson



# Time-of-flight detectors

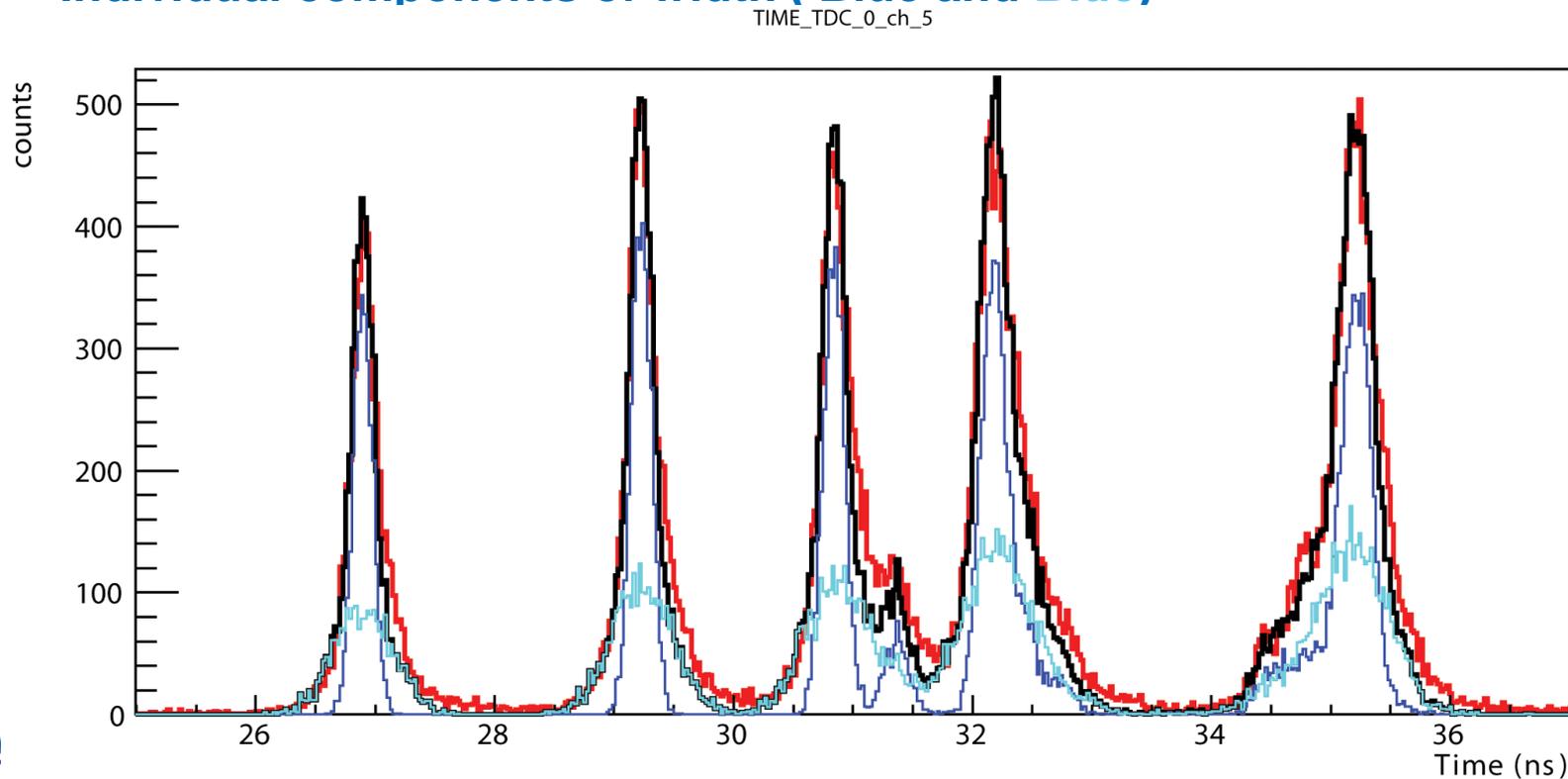
- **MCP plates used for fast time pick-off**
  - ~100 ps (FWHM) resolution possible
  - Large effective area: 75mm diameter with good timing
- **Electrostatic mirrors**
  - Fission fragment generate secondary electrons when passing through conversion foils
  - Electrostatic mirrors accelerate electrons and reflect them onto the MCPs
  - Geometric transmission through the grids is 98%
- **Delay-line anodes**
  - High spatial resolution ( $\mu\text{m}$ )
  - Fast readout ( $<100$  ns)
- **Analogue signal processing**
  - Fast preamps ( $>100$  MHz bandwidth)
  - Fast constant fraction discriminators



# Time of flight spectra for $^{229}\text{Th}$ alpha-source

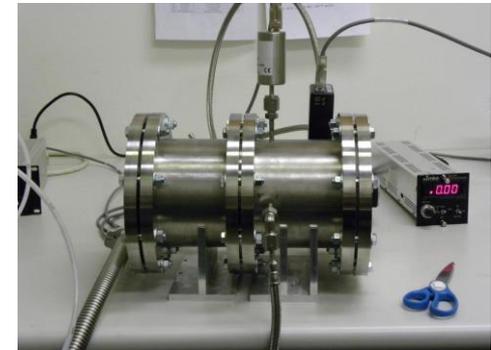
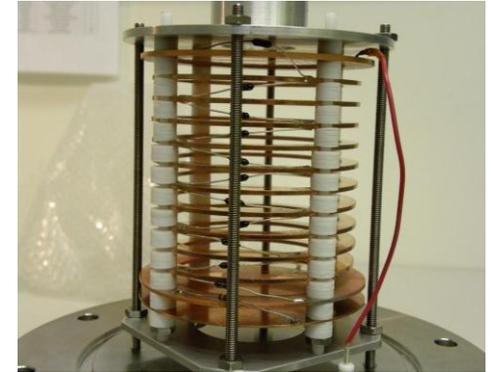
- **Data (Red)**
- **Overlaid Simulation (Black)**
- **Individual components of width (Blue and Blue)**

Figure courtesy of Charles Arnold



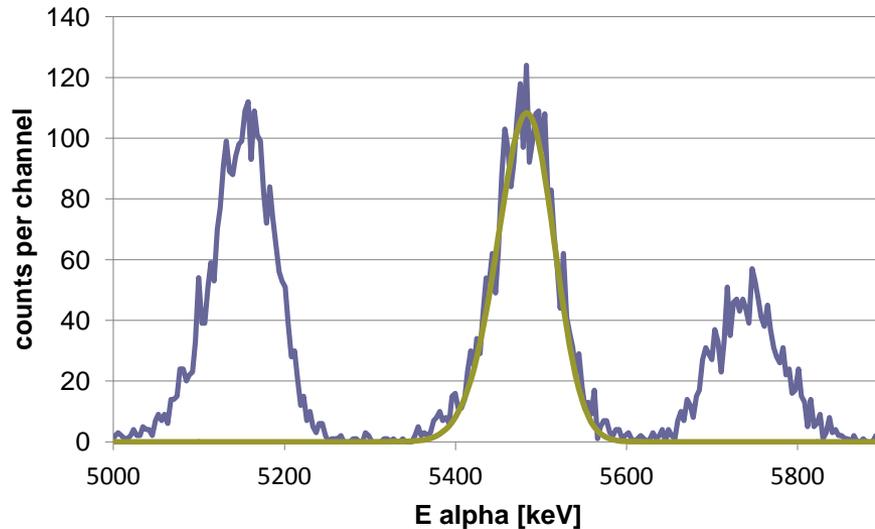
# Energy and Bragg peak detectors

- **Axial ionization chambers**
  - Ion enters chamber perpendicular to anode
  - Single anode (as supposed to segmented readout)
- **Energy resolution**
  - Best achieved (literature) 0.4% for light fragments and 0.8% for heavy fragments
- **Bragg peak spectroscopy**
  - For a fixed mass and energy the track length can be used to separate ion species
  - Pulse shape analysis in another option
- **Analogue signal processing**
  - Low-noise charge sensitive preamps



Pictures courtesy of Krista Meierbachtol

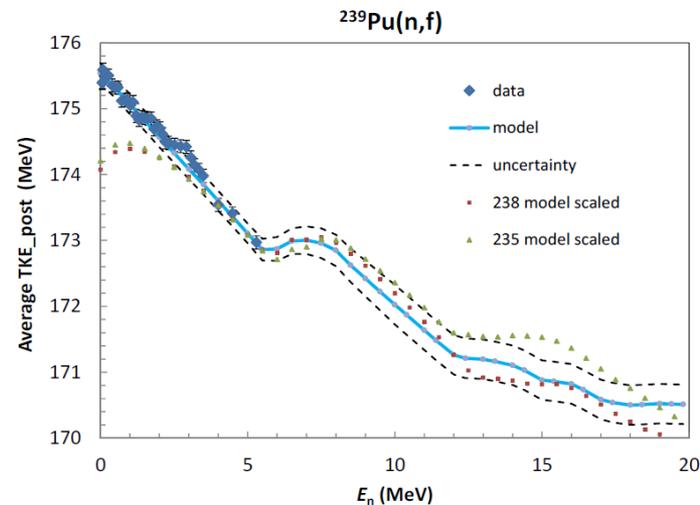
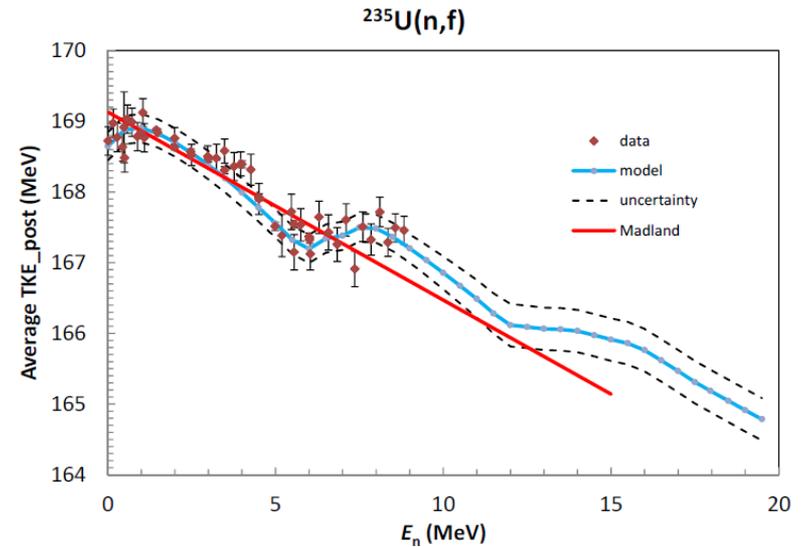
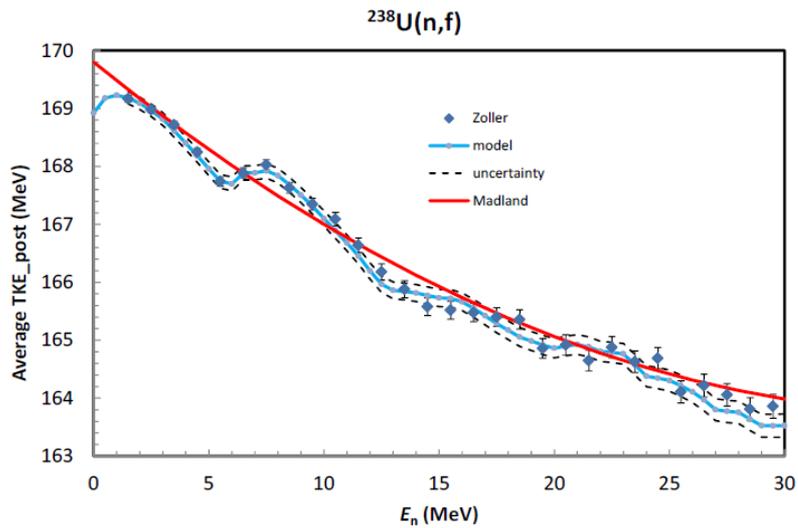
# First IC prototype commissioned, second prototype is being assembled



Alpha spectrum collected with 1<sup>st</sup> prototype IC using tri-nuclide source (Pu-239, Am-241, Cm-244)

- **First prototype**
  - P-10 gas, atmospheric pressure
  - No gas flow
  - Resolution for alphas is 1.3%
- **Second prototype**
  - Currently being assembled
  - Planned tests with P-10 and Isobutane
  - 150 Torr operating pressure
  - Planned testing with SiN windows

# Example – Lestone model for Post-Prompt Emission Fission Fragment TKE



# Timeline

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## ■ FY2013

- Scale up
  - Design system for up to 32 stop detectors
- First beam experiments
  - Single or dual arm setup
  - Thermal measurement (Lujan Center)
  - U-235 or Pu-239

## ■ FY2014

- Calibration/benchmarking of full system with Cf-252 spontaneous fission
- Thermal/epi-thermal measurement for Pu-239 with dual-arm
- First data on Pu-239 for fast spectrum (WNR)

## ■ FY15 & beyond

- Finalize data for Pu-239
- Move to other isotopes: U-235, U-238,...

# Conclusions

- **Exciting time for fission research at LANSCE-WNR**
  - Parallel-plate measurements continue
  - New technologies as well
- **TPC**
  - Moving from development to data collection and analysis
  - U-238/U-235 result scheduled for beginning of FY14
- **SPIDER**
  - Starting second of three-year LDRD
  - Scale up this year
  - First beam data this year

